

## Pt-Ni and Pt-Co Catalyst Synthesis Route for Fuel Cell Applications

**The main objective is to increase the overall efficiencies of fuel cell systems to support power for manned lunar bases.**

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Oxygen reduction reactions (ORRs) at the cathode are the rate-limiting step in fuel cell performance. The ORR is 100 times slower than the corresponding hydrogen oxidation at the anode. Speeding up the reaction at the cathode will improve fuel cell efficiency.

The cathode material is generally Pt powder painted onto a substrate (e.g., graphite paper). Recent efforts in the fuel cell area have focused on replacing Pt with Pt-X alloys (where X = Co, Ni, Zr, etc.) in order to (a) reduce cost, and (b) increase ORR rates. One of these strategies is to increase ORR rates by reducing the powder size, which would result in an increase in the surface area, thereby facilitating faster reaction rates.

In this work, a process has been developed that creates Pt-Ni or Pt-Co al-

loys that are finely divided (on the nano scale) and provide equivalent performance at lower Pt loadings. Lower Pt loadings will translate to lower cost.

Precursor salts of the metals are dissolved in water and mixed. Next, the salt mixtures are dried on a hot plate. Finally, the dried salt mixture is heat-treated in a furnace under flowing reducing gas. The catalyst powder is then used to fabricate a membrane electrode assembly (MEA) for electrochemical performance testing. The Pt-Co catalyst-based MEA showed comparable performance to an MEA fabricated using a standard Pt black fuel cell catalyst.

The main objective of this program has been to increase the overall efficien-

cies of fuel cell systems to support power for manned lunar bases. This work may also have an impact on terrestrial programs, possibly to support the effort to develop a carbon-free energy source. This catalyst can be used to fabricate high-efficiency fuel cell units that can be used in space as regenerative fuel cell systems, and terrestrially as primary fuel cells. Terrestrially, this technology will become increasingly important when transition to a hydrogen economy occurs.

*This work was done by Samad A. Firdosy, Vilupanur A. Ravi, Thomas I. Valdez, and Adam Kisor of Caltech; and Sri R. Narayan of USC for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47885*

## Aerogel-Based Multilayer Insulation With Micrometeoroid Protection

**The aerogel's hydrophobic nature ensures thermal performance when exposed to the environment.**

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Ultra-low-density, highly hydrophobic, fiber-reinforced aerogel material integrated with MLI (aluminized Mylar reflectors and B4A Dacron separators) offers a highly effective insulation package by providing unsurpassed thermal performance and significant robustness, delivering substantial MMOD protection via the addition of a novel, durable, external aerogel layer. The hydrophobic nature of the aerogel is an important property for maintaining thermal performance if the material is exposed to the environment (i.e. rain, snow, etc.) during ground installations.

The hybrid aerogel/MLI/MMOD solution affords an attractive alternative because it will perform thermally in the same range as MLI at all vacuum levels (including high vacuum), and offers significant protection from micrometeoroid damage. During this effort, the required low-density and resilient aerogel materials have been developed that are needed to opti-

mize the thermal performance for space (high vacuum) cryotank applications.

The proposed insulation/MMOD package is composed of two sections: a stack of interleaved aerogel layers and MLI intended for cryotank thermal insulation, and a 1.5- to 1-in. ( $\approx 2.5$ - to 3.8-cm) thick aerogel layer (on top of the insulation portion) for MMOD protection. Learning that low-density aerogel cannot withstand the hypervelocity impact test conditions, the innovators decided during the course of the program to fabricate a high-density and strong material based on a cross-linked aerogel (X-aerogel; developed elsewhere by the innovators) for MMOD protection.

This system has shown a very high compressive strength that is capable of withstanding high-impact tests if a proper configuration of the MMOD aerogel layer is used. It was learned that by stacking two X-aerogel layers [1.5-in.

( $\approx 3.8$ -cm) thick] separated by an air gap, the system would be able to hold the threat at a speed of 5 km/s and "pass" the test. The first aerogel panel stopped the projectile from damaging the second aerogel panel. The impacted X-aerogel (the back specimen from the successful test) was further tested in comparison to another similar sample (not impacted) at Kennedy Space Center for thermal conductivity evaluation at cryogenic conditions. The specimens were tested under high vacuum and cryogenic temperatures, using Cryostat 500. The results show that the specimen did not lose a significant amount of thermal performance due to the impact test, especially at high vacuum.

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